LJ-82-14

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JUNE 1982

PRELIMINARY REPORT ON THE USE OF NON-METRICAL SKULL CHARACTERS TO DISCRIMINATE POPULATIONS OF PELAGIC DOLPHINS

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Administrative Report No. LJ-82-14

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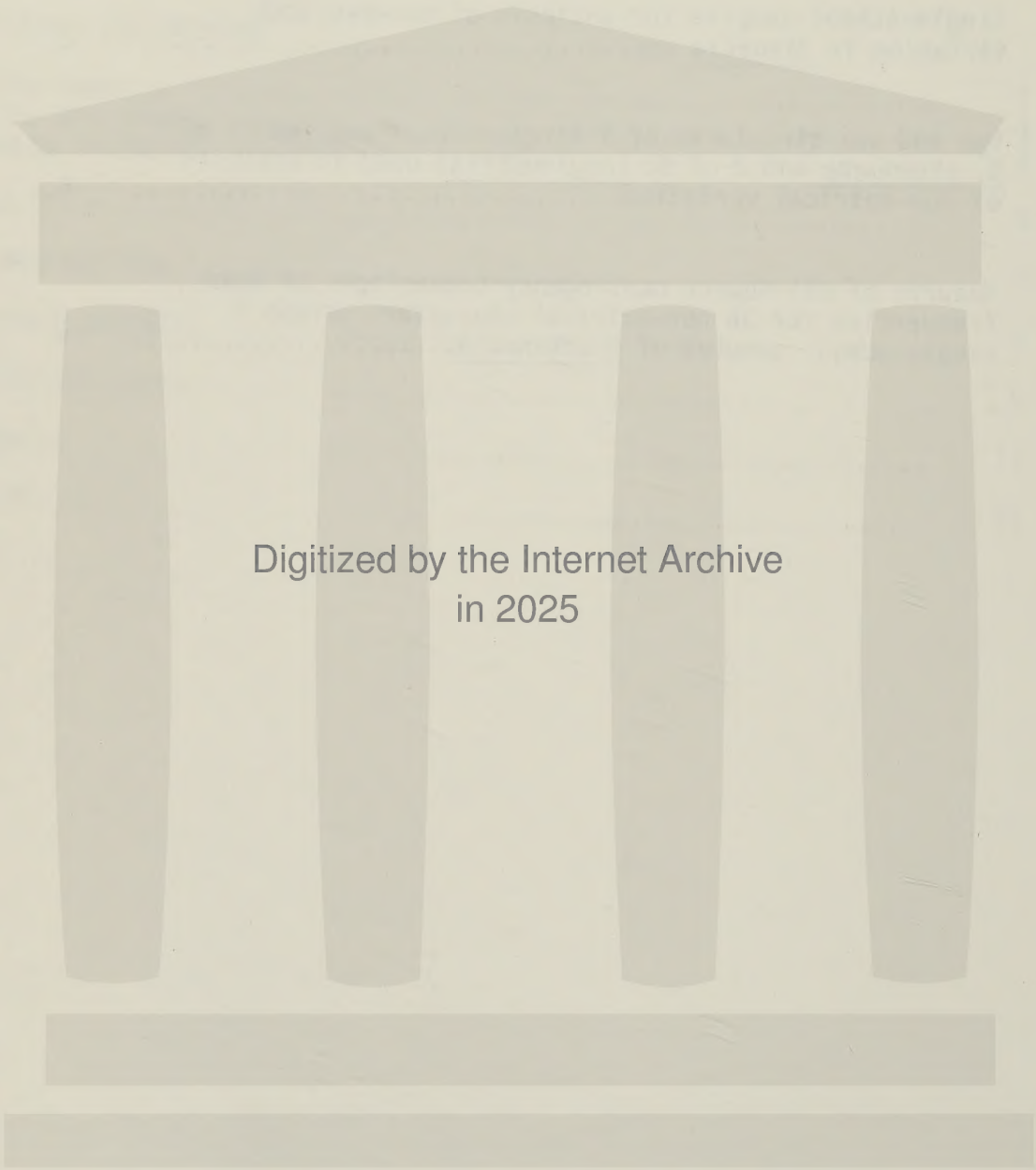

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INTRODUCTION

Pelagic dolphins are killed incidentally in the international purse seine fishery for yellowfin tuna, Thunnus albacares, in the eastern tropical Pacific (Perrin, 1969; Perrin and Oliver, 1981; Allen and Goldsmith, 1981). Rational management of the dolphins requires delineation of breeding populations, or "stocks" and designation of management units (Smith, 1979). Previous analyses of geographical variation in morphology to delineate populations have been based on color pattern, external measurements, and measurements and meristics of the skull and post-cranial skeleton (Perrin, 1972, 1975a and b; Perrin, Sloan and Henderson, 1979). Analyses of patterns in distribution and in environmental variables have also contributed to delineation of stocks (Au, Perryman and Perrin, 1979). In the systematics of mammals, much attention has recently focused on the use of non-metrical characters (Yablokov, 1966; Sjøvold, 1973 and 1977; Hartman, 1980; Yablokov and Evans, in press). Because non-metrical characters of the skull have relatively high inheritability and because most, if not all, of them probably are adaptively neutral, they are potentially valuable indices of genetic divergence between populations that is primarily due to genetic drift. The purpose of this paper is to report the results of a preliminary investigation of the potential of non-metrical cranial characters for analysis of geographical variation in dolphins involved in the tuna fishery.

MATERIALS AND METHODS

The Samples

The skulls examined are from dolphins killed in the tuna fishery by commercial seiners and collected by NMFS technician (see Perrin, 1969 for description of the purse seining operation). The 11 single-school samples contained 385 specimens of Stenella attenuata and 34 of S. longirostris (Table 1). The present report deals with samples I-IV and IX-XI. The remaining four samples will be given fuller treatment in further analyses. The samples of S. attenuata spanned an area roughly 600 x 1000 NM off southern

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Table 1. Single-school samples for analysis of non-metrical variation in *Stenella* spp.

Sample (& collector)	Species (& stock)	Sample size	Locality	Date	Data	
					Complete	Photos only
I, (WFP-CV)	*S. attenuata* (N. offshore)	28	7°11'N,90°32'W	12 Apr 68	x	
II, (WFP-CV)	"	37	12°51'N,93°18'W	9 Apr 68	x	
III, (JMC)	"	62	11°23'N,108°10'W	14 Oct 72	x	
IV, (CWO)	"	50	8°20'N,104°50W	17 Jan 73	x	
V, (JMC)	"	58	11°56'N,109°03'W	9 Oct 72		x
VI, (JMC)	"	51	14°02'N,109°15'W	4 Oct 72		x
VII, (JMC)	"	52	10°28'N,104°05'W	23 Oct 72		x
VIII, (JMC)	"	39	11°31'N,108°15'W	14 Oct 72		x
IX, (CWO)	*S. longirostris* (N. whitebelly)	20	12°34'N,95°40'W	24 Apr 72	x	
X, (BGB)	*S. longirostris* (S. whitebelly)	14	12°52'S,83°32'W	18 Jan 80	x	
XI, (DJT)	*S. attenuata* (Coastal)	8*	20°26'N,106°32'W	13 Apr 79	x	
Totals:						
	S. attenuata	385	-	-	5	4
	S. longirostris	34	-	-	2	0
	Both species	419	-	-	7	4

*Four more specimens still frozen; will be included in further studies.

Mexico and Central America (Figure 1). The two samples of S. longirostris were from localities some 2,000 NM apart. Each specimen consisted of a calvarium and the mandibular rami, although in some cases the rami were missing or bones were broken, resulting in some missing values in the data.

The samples were roughly equivalent in age and sex structures within each of the two species (Table 2).

The Characters

The 36 characters used are listed and described in Appendix 1. A number of additional characters were considered but dropped, as insufficiently variable, inadequately definable, or obviously related to growth.

Data Collection and Analysis

Data collection consisted of two phases: 1) Yablokov and Perrin each scored the same sample of skulls (Sample I) independently and compared and discussed our respective data; 2) upon feeling assured that we agreed on the definitions of the characters and their variants, we scored all 7 of the samples for which complete data were collected, in serial order. One of us (AVY) examined and scored the skulls, and the other (WFP) recorded the data, with consultation on problematic skulls and difficult characters. The skulls were coded for characters 1-6 from enlarged black and white dorsal photographs taken perpendicular to the long axis of the skull. For samples IV through VIII, only these data were collected (Table 1).

For this preliminary examination of feasibility of the method, we analyzed the data for samples I-IV and IX-XI one character at a time. First, to examine variation among schools of a single stock, we tested the null hypothesis of no difference among the samples from four northern offshore schools of S. attenuata, using a chi-square contingency analysis. We then did the same for the four northern-offshore samples pooled (I-IV) versus the single small sample from a coastal school (XI), but only considering those characters for which the null hypothesis was rejected in the first analysis at >0.05. For the two small samples of S. longirostris, we merely scanned the differences in means to determine whether the same characters that showed significant variation among the samples of S. attenuata are likely to be the most useful for this species as well.

RESULTS

Differences among the samples are apparent (Appendix 2) and statistically significant at >0.05 for 13 of 36 characters (36%) in the case of the comparison of the offshore samples to each other and 6 of 13 characters (46%) in the comparison of the pooled offshore samples with the coastal sample (Table 3). This incidence is considerably higher than the 5% to be expected on the basis of chance alone.

In comparing the two small S. longirostris samples (IX and X), it is apparent that while there is some transfer of useful characters across species, considerable species specificity may exist as well. Of 13 characters for which there was at least 20 percentage points difference in state-frequency between the two samples for at least one state, 6 (characters

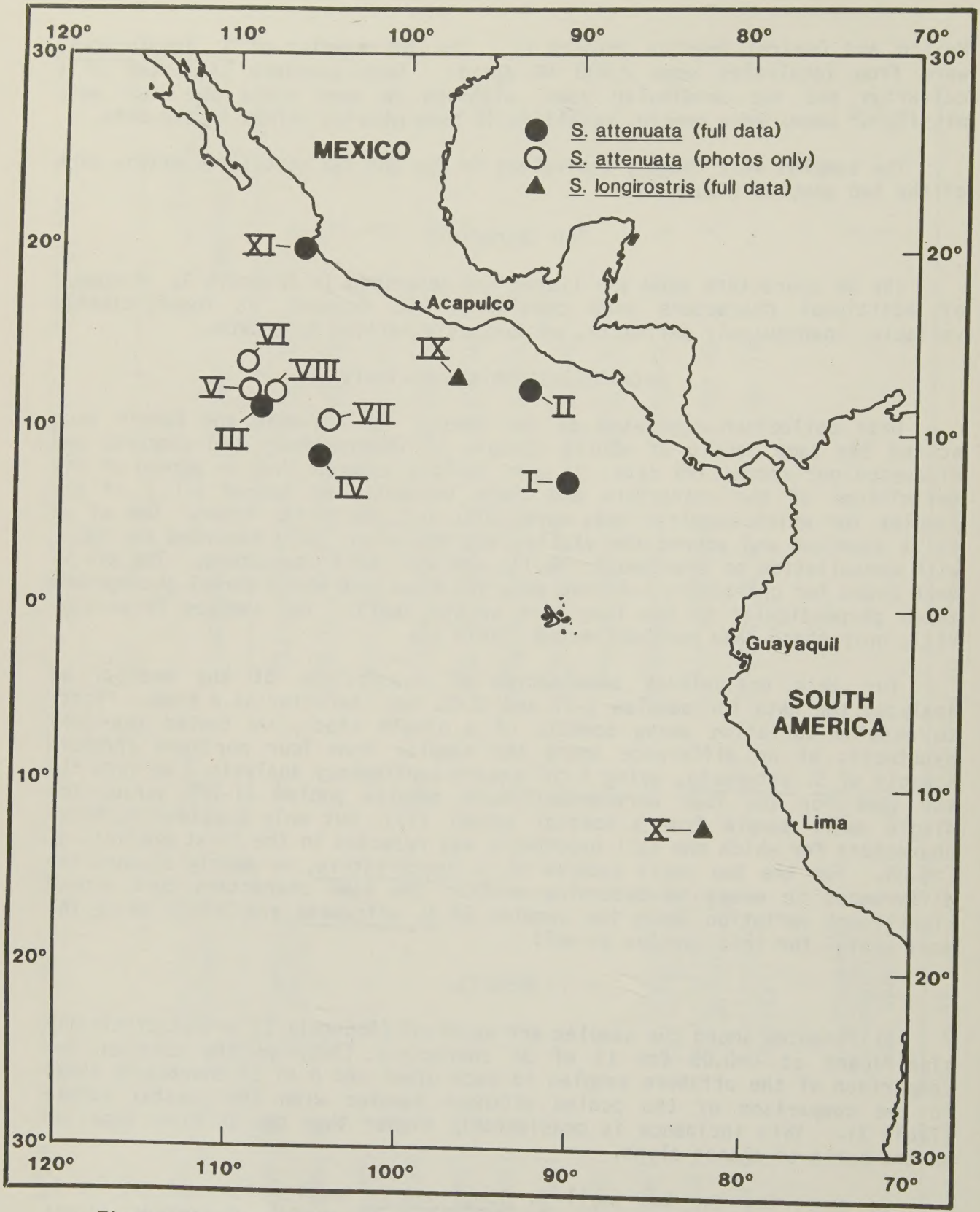

Figure 1. Localities for single-school samples used in analysis of non-metrical variation in Stenella spp.

Table 2. Age and sex structures of 7 single-school samples (5 of S. attenuata and 2 of S. longirostris) used in analyses of non-metrical variation.

School	N	Sexually adult* n	Sexually adult* (%)	Males n	Males (%)
I. (S. attenuata--N. offshore)	28	10	(36)	16	(57)
II. (" ")	37	15	(41)	21	(57)
III. (" ")	62**	30	(48)	21	(34)
IV. (" ")	50	28	(56)	26	(52)
IX. (S. longirostris--N. whitebelly)	20	16	(80)	12	(60)
X. (" --S. whitebelly)	14	13	(93)	8	(57)
XI. (S. attenuata--Coastal)	8	4	(50)	5	(63)
Total for S. attenuata	185	87	(47)	89	48
Total for S. longirostris	34	29	(85)	20	59

*Inferred from distal fusion of PMX and MX bones.
**Including one specimen of unknown sex.

Table 3. Results of chi-square contingency comparisons of mean frequencies for 36 non-metrical characters across 5 single-school samples of S. attenuata.

Character*	Schools I, II, III & IV				I-IV** Pooled & XI***	
	Null hypothesis rejected at α =					
	>0.10	0.10	0.05	0.01	>0.05	0.05
1. (states 2 & 3 pooled--see text)			x			x
2. (" 1 & 2 ")	x				-	
3.	x				-	
4.	x				-	
5. (" 1-3 ")				x	x	
6. (" 1-3 ")	x				-	
7. (" 2-5 ")			x		x	
8.				x	-	x
9.			x		x	
10.	x				-	
11.			x		x	
12.				x	x	
13.	x				-	
14. (" 4-6 ")	x				-	
15.			x		x	
16.	x				-	
17.	x				-	
18. (" 1-3 ")	x				-	
19. (" 1&2 ")		x			-	
20.			x		-	x
21. (" 4&5 ")				x	-	x
22.				x	-	x
23.		x			-	
24.	x				-	
25.	x				-	
26.			x			x
27.	x				-	
28. (states 2-6 pooled)	x				-	
29. (" 3-8 ")	x				-	
30.	x				-	
31. (" 2-8 ")	x				-	
32.	x				-	
33. (" 3-6 & 7-10")	x				-	
34.				x	x	
35.	x				-	
36.	x				-	
Total	21	2	7	6	7	6
(Percent)	(58.3)	(5.6)	(19.4)	(16.7)	(53.9)	(46.1)
			(36.1)			

*For characters having left and right components, only left are included here.
**Northern offshore stock.
***Coastal stock

no. 1, 15, 20, 21, 22 and 34), or 46%, are among the 13 characters for which statistically real variation among samples was found for the 4 northern offshore spotted samples of S. attenuata, i.e., there may be only about a 50% overlap in the best sets of discriminating characters for the two species. This finding is provisional, because of the relatively small sample sizes for S. longirostris. The characters differing most consistently between samples in all of the comparisons above are several (nos. 1, 20, 21 and 22) having to do with number and position of foramina.

RECOMMENDATIONS

The method appears promising and could be applied to the additional existing large single-school samples of pelagic dolphins. Appropriate questions of interest in the management of dolphins in the ETP are:

1. Should offshore spotted dolphins south of the equator be considered a separate stock?

2. Should whitebelly spinner dolphins south of the equator be considered a separate stock?

3. What is the degree of east-west migration and genetic mixing within the range of the northern offshore spotted dolphin?

4. Do distinct subpopulations exist within the range of the eastern spinner dolphin?

5. Are the geographically-defined stocks of tropical common dolphins, Delphinus delphis, morphologically distinct?

6. Are the geographically-defined stocks of tropical striped dolphins, Stenella coeruleoalba, morphologically distinct?

Analysis of the more comprehensive bodies of data should more rigorously examine the effects of growth and should utilize appropriate multivariate techniques, as was done by Hartman (1980), in his analysis of geographical variation of Dipodomys and by Sjøvold (1973 and 1977) and others in analyses of nonmetric variation in humans.

ACKNOWLEDGEMENTS

The research was carried out as part of the Marine Mammal Project under the U.S.-U.S.S.R. Environmental Agreement of 1972. Our thanks go to V. A. Zemskiy, R. V. Miller, N. A. Popov, S. G. Kohl, W. Silverman and others who have made the Marine Mammal Project work.

J. M. Coe, W. Oliver, B. G. Bargo and D. J. Trudeau collected most of the dolphins. We also wish to thank the owners, captains and crews of the tuna seiners Carol Virginia, Eastern Pacific, Independence, King Oscar and Lois Seaver for their invaluable assistance and cooperation.

J. G. Mead of the U.S. National Museum of Natural History, Washington, D.C., provided extensive assistance, we well as making it possible for us to examine the material in the USNM collection. A. Rea kindly allowed us to examine material in the collection of the San Diego Museum of Natural History.

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APPENDIX 1. Description of the non-metrical characters.

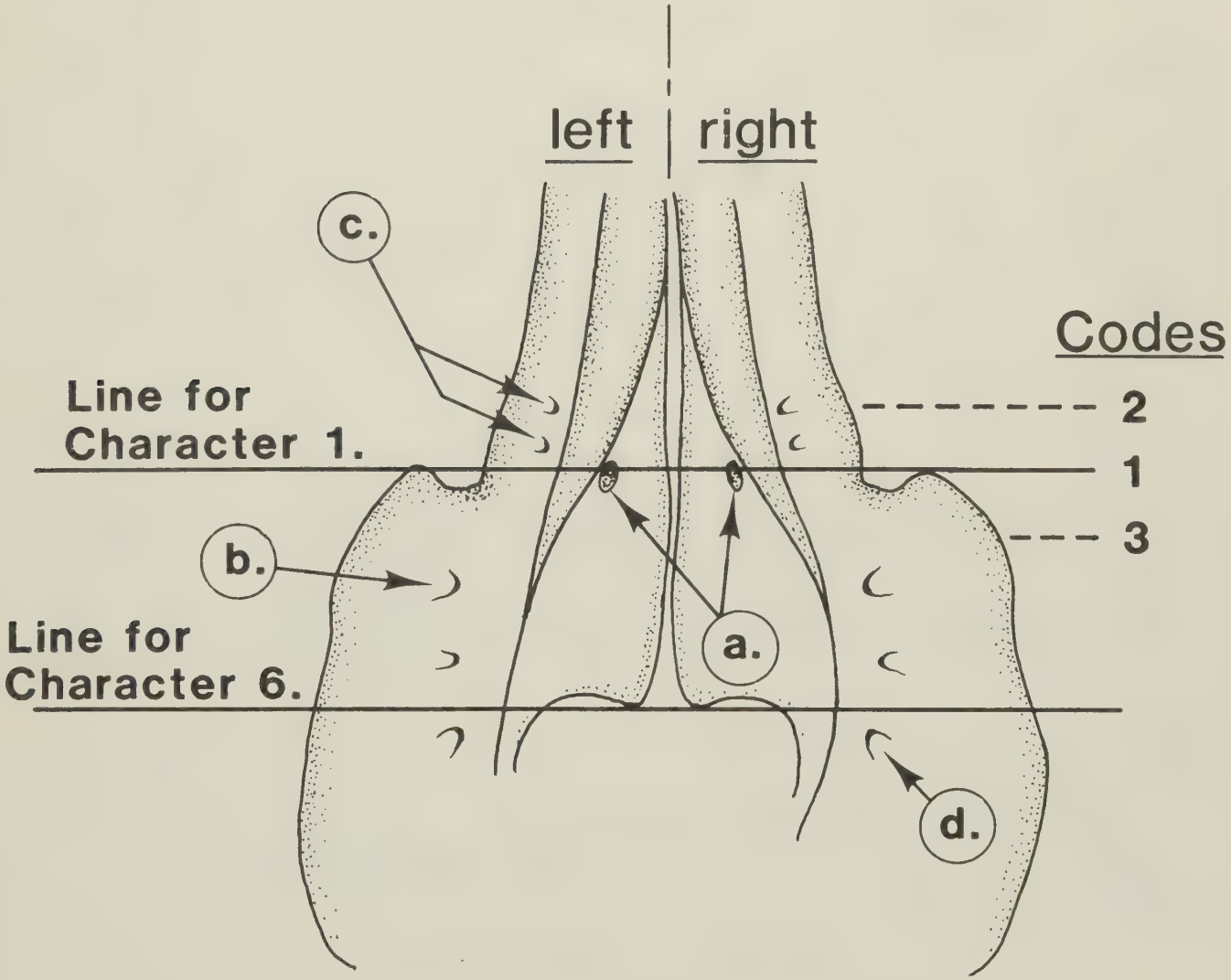
THE FACE AND CALVARIUM

IN DORSAL VIEW

Character 1. (left and right)

Position of the foramen (a below) in the premaxillary at the base of the prenarial triangle, relative to the level of the anteriormost projection of the antorbital processes.

Codes: 1 = at, 2 = ahead, 3 = behind the level.



Character 2. (left and right)

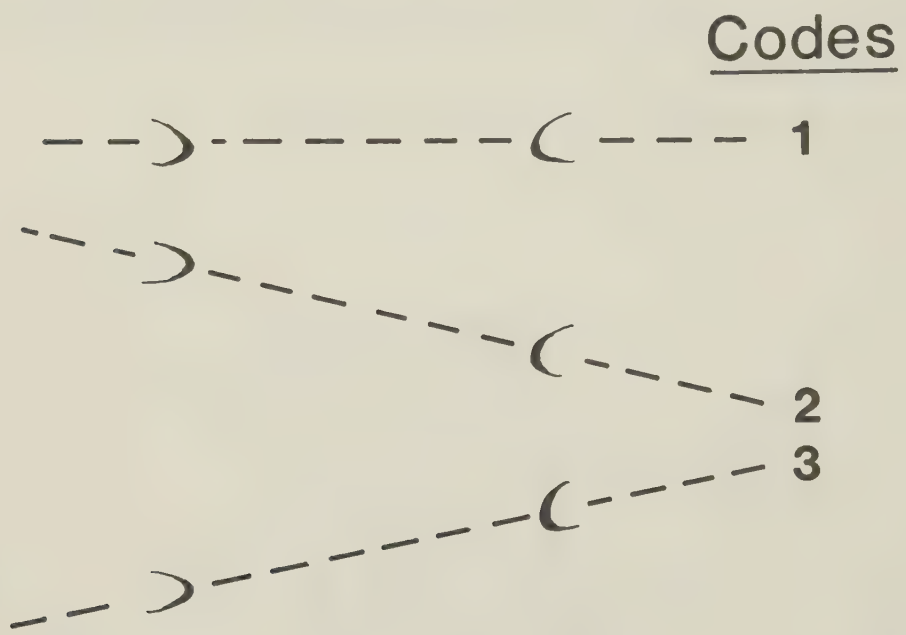
Position of the anteriormost of the three large foramina (b above) in the maxillary relative to the level of the anteriormost projection of the antorbital processes.

Codes: 1 = at, 2 = ahead, 3 = behind the level.

Character 3.

Asymmetry of position of the two anteriormost large maxillary foramina (b. above).

Codes: 1 = symmetrical, 2 = left foramen more anteriorly placed, 3 = right foramen more anterior.



Character 4. (left and right)

Vertical perforation (visible in vertical view) of the maxillary by the anteriormost large foramen (b. in figure above under Character 1.).

Codes: 1 = vertical perforation, 2 = no vertical perforation (perforation may be absent or may be present but not visible in vertical view).

Character 5. (left and right)

Number of small foramina (c. in figure above) in the maxillary anterior to the anteriormost of the three large foramina.

Codes: 1 = 1 foramen, 2 = 2, 3 = 3, 4 = 4, 5 = 5, 6 = 0.

Character 6. (left and right)

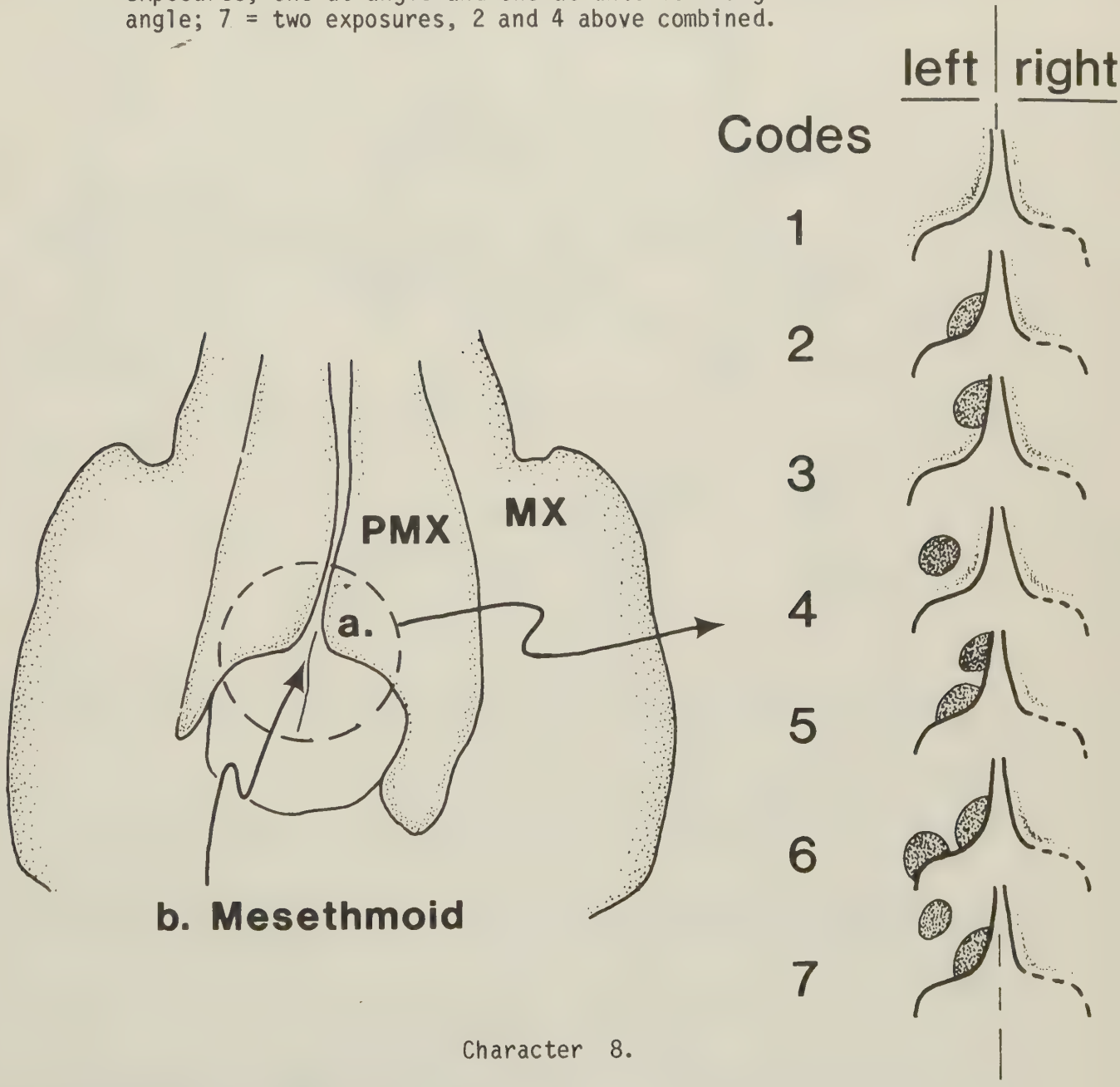
Number of foramina (d. in figure) in the maxillary behind a line at the level of the anterior edge of the external nares and perpendicular to the long axis of the skull (see figure above).

Codes: 1 = foramen, 2 = 2, 3 = 3, 6 = 0.

Character 7. (left and right)

Number and position of exposures of the maxillary through the premaxillary in the prenarial triangle (a. in figure below).

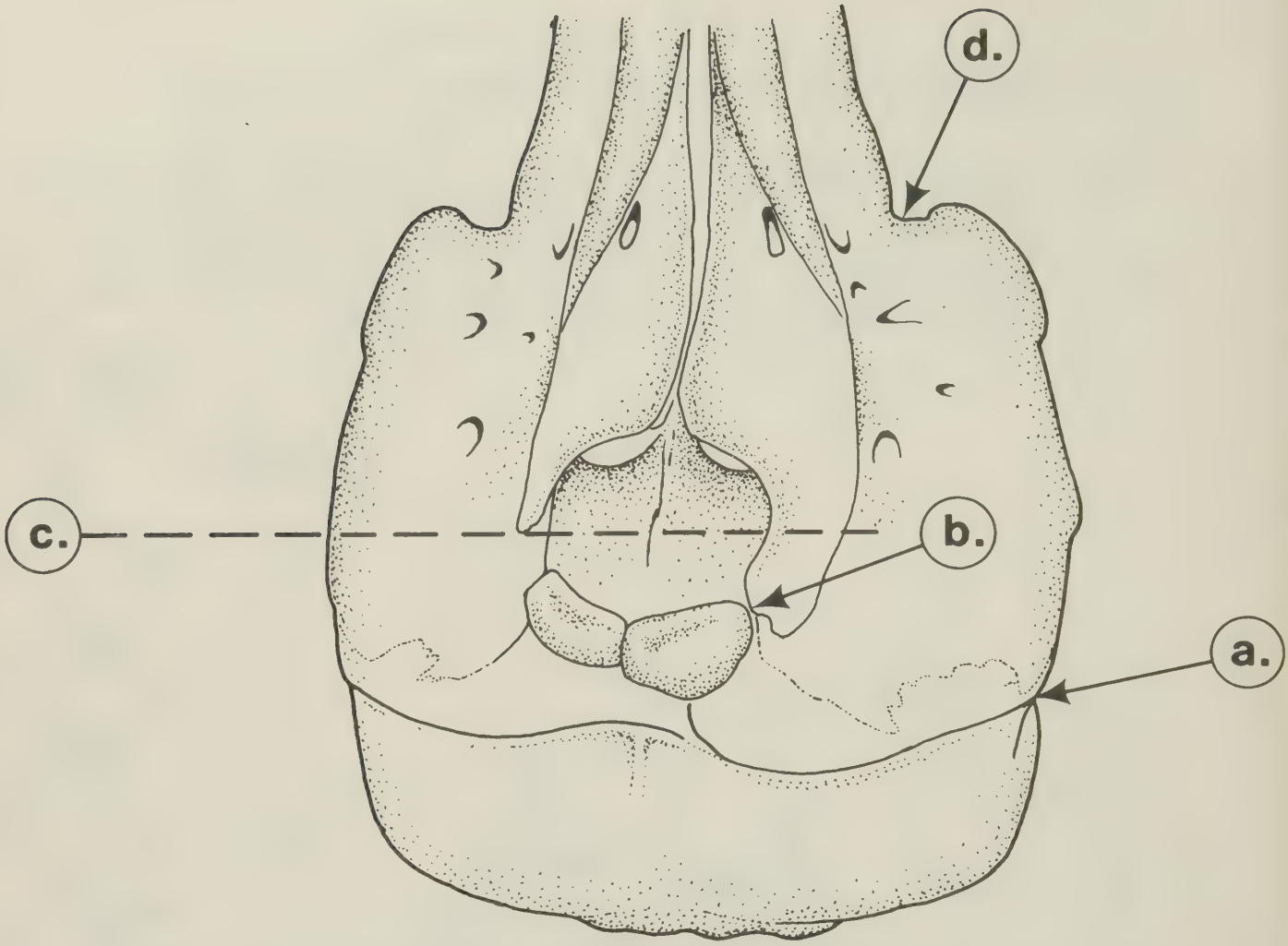
Codes: 1 = no exposure of the maxillary; 2 = one exposure, at mesial angle of premaxillary; 3 = one exposure, at mesial margin of premaxillary but not adjacent to nares; 4 = one exposure, not at margin of premaxillary; 5 = two exposures, 2 and 3 above combined; 6 = two exposures, one at angle and one at anterior margin of nares lateral of angle; 7 = two exposures, 2 and 4 above combined.



Character 8.

Development of dorsal mesethmoid spine at anterior margin of external nares, between angles of premaxillaries (b. in figure above).

Codes: 1 = elevation of the ossified portion of the mesethmoid to, or near to, the level of the dorsal surfaces of the premaxillaries; 2 = no such elevation.



Character 9. (left and right)

Contact between maxillary and occipital, at point where occipital crest intersects margin of temporal fossa (a. in figure bove)

Codes: 1 = contact (or space of <1mm), 2 = no contact

Character 10.

Contact between premaxillary and nasal, on right side (b. in figure above)

Codes: 1 = contact (or space of <1mm), 2 = no contact.

Character 11. (left and right)

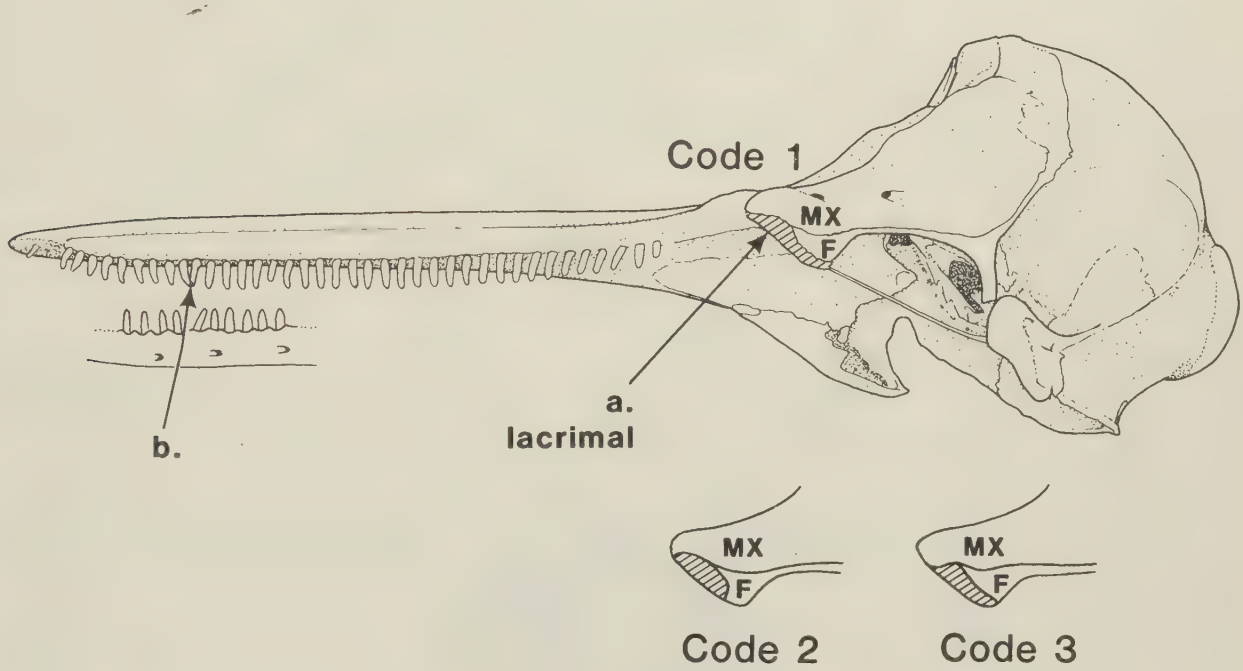
Composition of dorsal rim of external nares at level of posteriormost extension of premaxillary on left side (c. in figure above), in vertical view.

Codes: 1 = composed of premaxillary only, 2 = composed of premaxillary and maxillary.

Character 12. (left and right)

Presence of an antorbital notch (d. in figure above).

Codes: 1 = notch present, 2 = not present



Character 13.

Composition of the antorbital process, in lateral view, on left side (a. in figure above).

Codes: 1 = formed by lacrimal, 2 = formed by lacrimal and frontal, 3 = formed by lacrimal and maxillary.

Character 14.

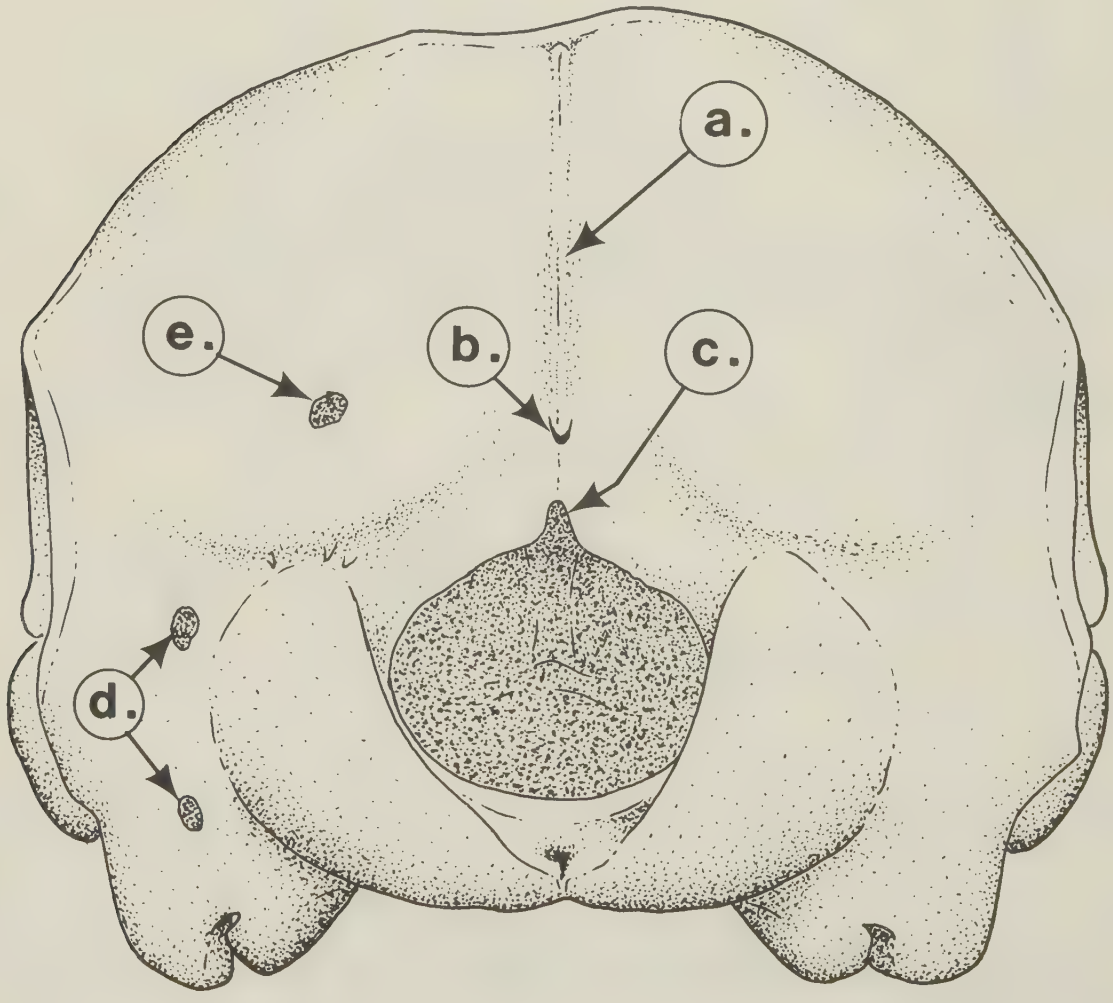
Total number of dental malocclusions (b. in figure above) on both sides combined.

Codes: 1 = 1 malocclusion, 2 = 2, 3 = 3, 4 = 4, 5 = 5, 6 = 0

Character 15.

Medial occipital ridge (a. in figure below), projecting above level of the occipital swellings at midheight.

Codes: 1 = present, 2 = absent, or not projecting above swellings.



Character 16. (left and right)

Accessory foramen above foramen magnum (b. in figure above).

Codes: 1 = present, 2 = absent.

Character 17.

Clear notch in upper margin of foramen magnum (c. in figure above).

Codes: 1 = present, 2 = absent.

Character 18. (left and right)

Fenestrations in occiptals, near foramen magnum and in exoccipital region (d. in figure on p. 19).

Codes: 1 = 1 fenestration, 2 = 2, 3 = 3, 6 = 0.

Character 19.

Fenestrations in region of occipital swellings (e. in figure on p. 19).

Codes: 1 = 1 fenestration, 2 = 2, 6 = 0.

IN VENTRAL VIEW

CHARACTER 20. (left and right, in ventral view)

Position of end of toothrow (center of last tooth, or center of alveolus if tooth missing; a. in figure on p. 21).

Character 21. (left and right, in ventral view)

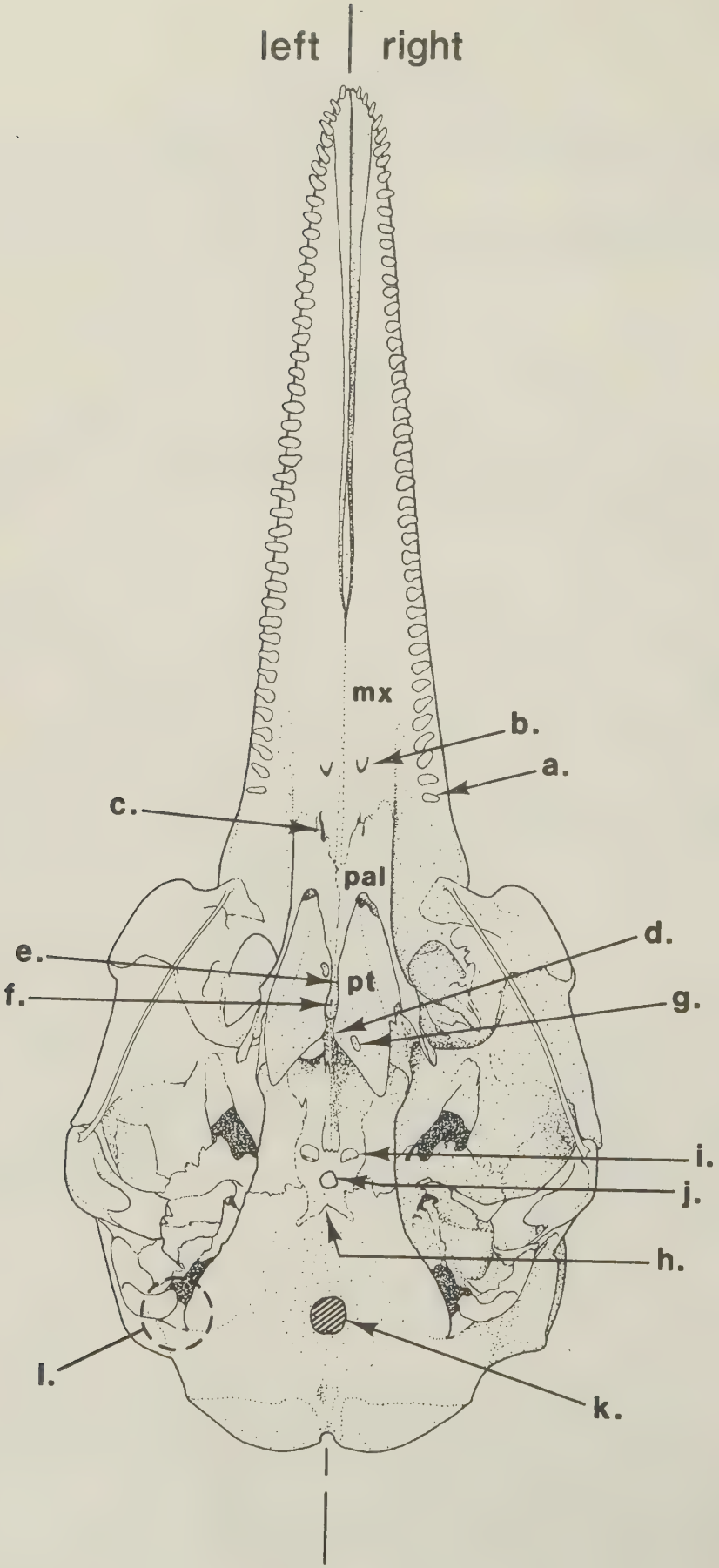
Position of anteriormost foramen in maxillary (b. in figure on p. 21).

Codes: 1 = at level of anteriormost projection of palatine, 2 = anterior to palatine, 3 = between palatines.

Character 22. (left and right, in ventral view)

Number of foramina (>1mm in diameter) along boundary between maxillary and palatine (c. in figure on p. 21).

Codes: 1 = 1 foramen, 2 = 2, 3 = 3, 4 = 4, 5 = 5, 6 = 0


left
right
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b.
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g.
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Character 23.

Posterior contact between pterygoid hamuli (d. in figure on p. 21).

Codes: 1 = open (gap ≥1mm), 2 = closed.

Character 24.

Anterior contact between hamuli (e. in figure on p. 21).

Codes: 1 = open (gap ≥1mm), 2 = closed.

Character 25.

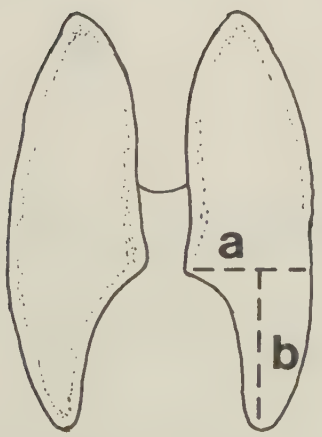
Spine of (palatines, vomer?) visible in anterior gap between hamuli (f. in figure on p. 21).

Codes: 1 = visible, 2 = not visible.

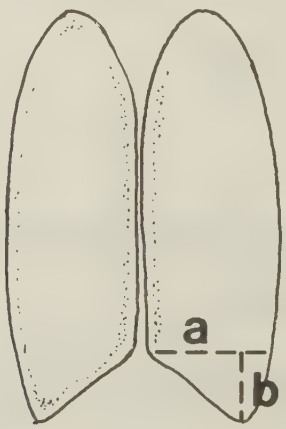
Character 26.

Shape of posterior projection of (left) pterygoid hamulus.

Codes: 1 = longer than wide, 2 = wider than long, or equal.



Code 1 (b>a)



Code 2 (a≥b)

Character 27.

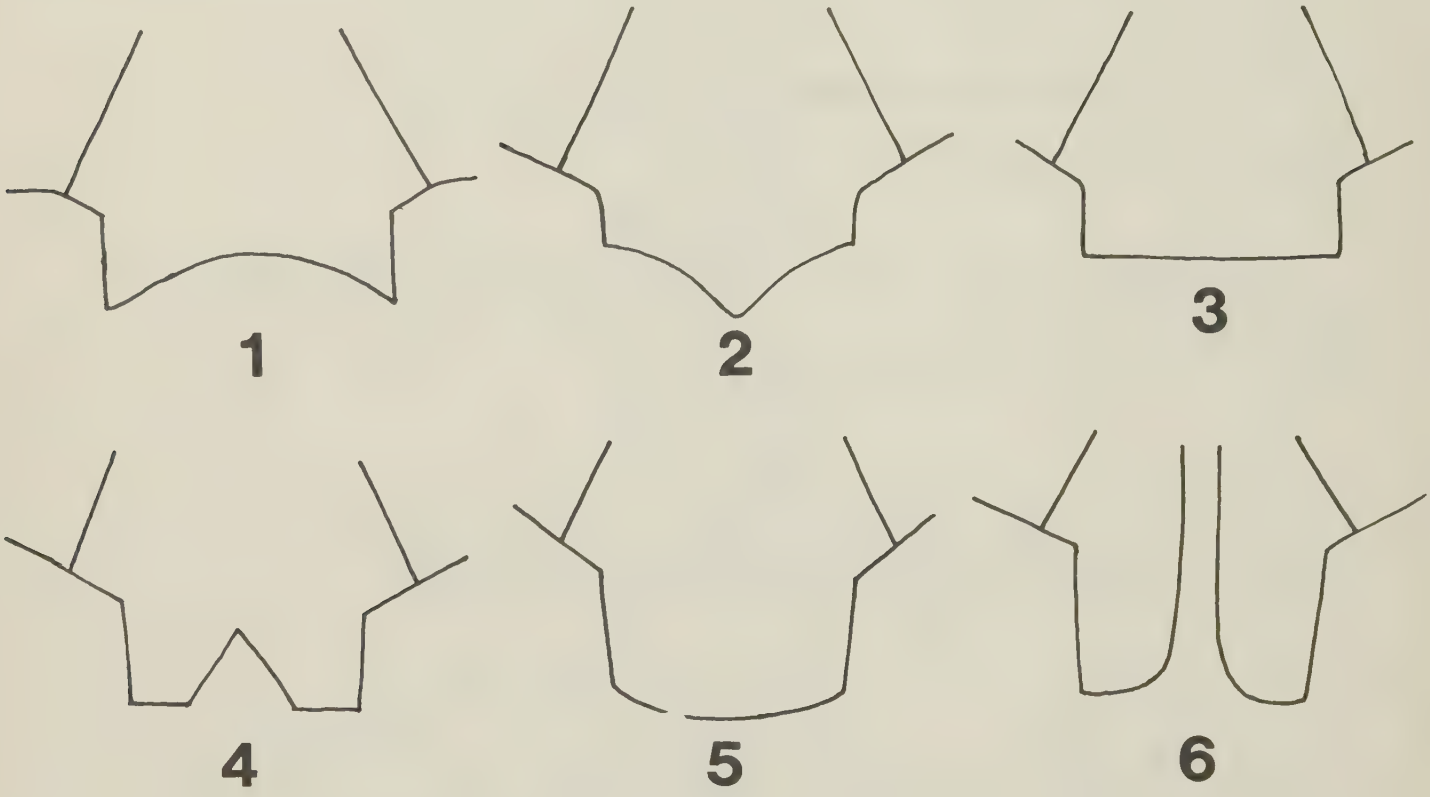
Fenestration(s) (≥1mm in diameter) in posterior half of hamuli (g. in figure on p. 21).

Codes: 1 = fenestration(s) present, 2 = absent.

Character 28.

Shape of posterior margin of basisphenoid (h in figure on p. 21).

Codes :

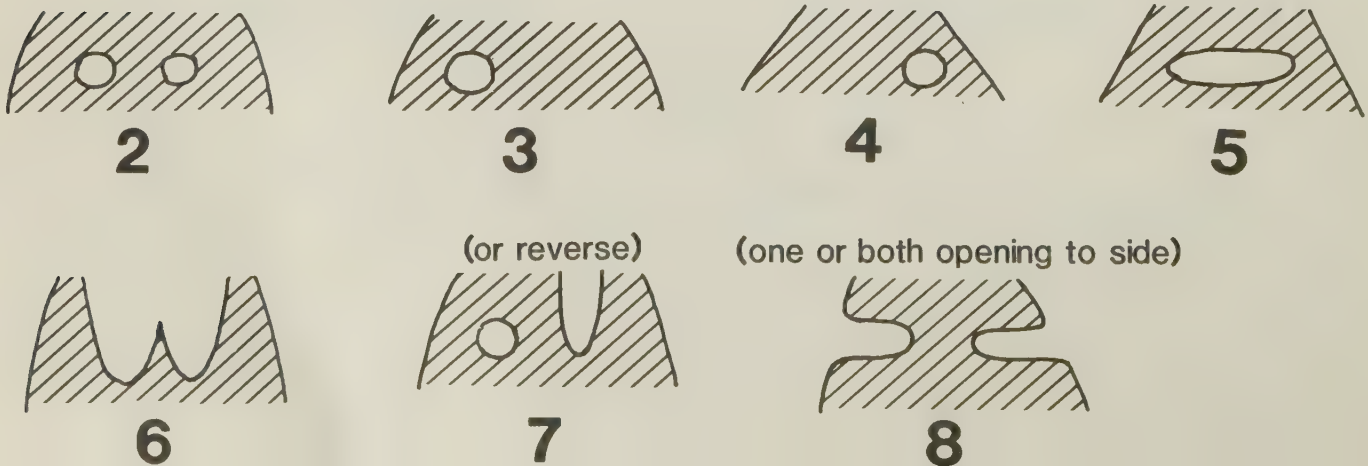


Character 29.

Lateral fenestration(s) in basisphenoid (i. in figure on p. 21).

Codes :

1 = no fenestration



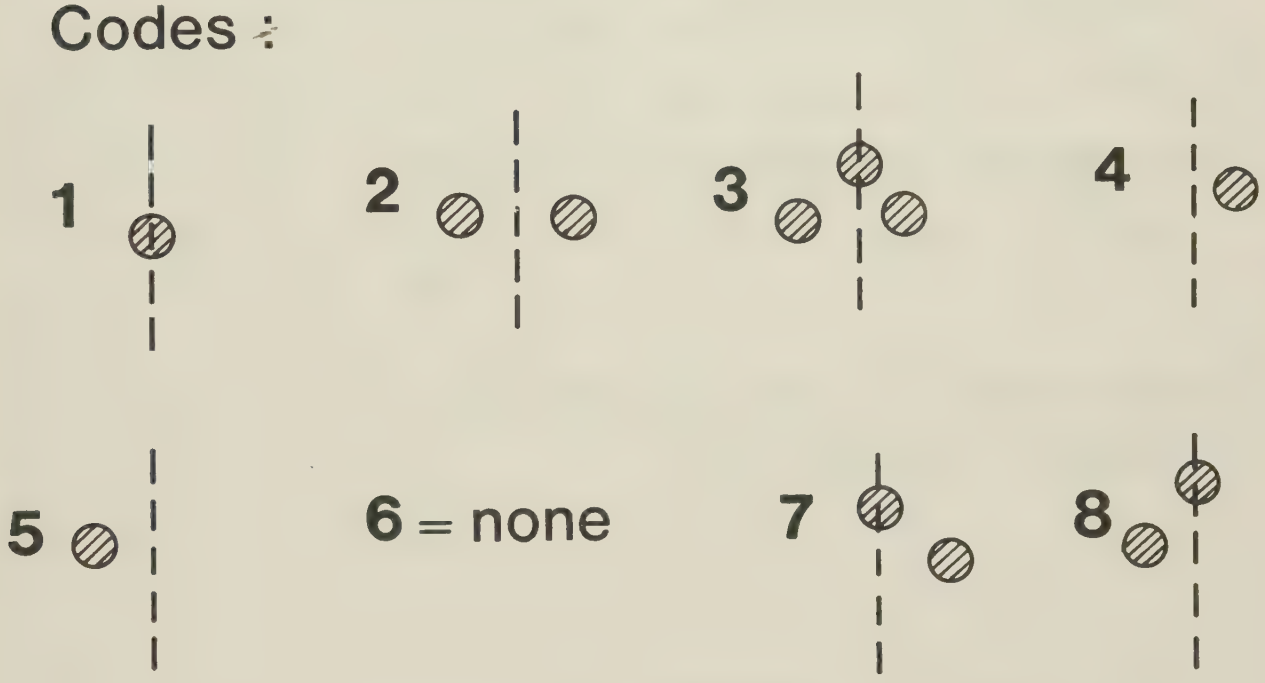
Character 30.

Mesial fenestration in basispenoid (j. in figure on p. 21).

Codes: 1 = foramen present, 2 = absent.

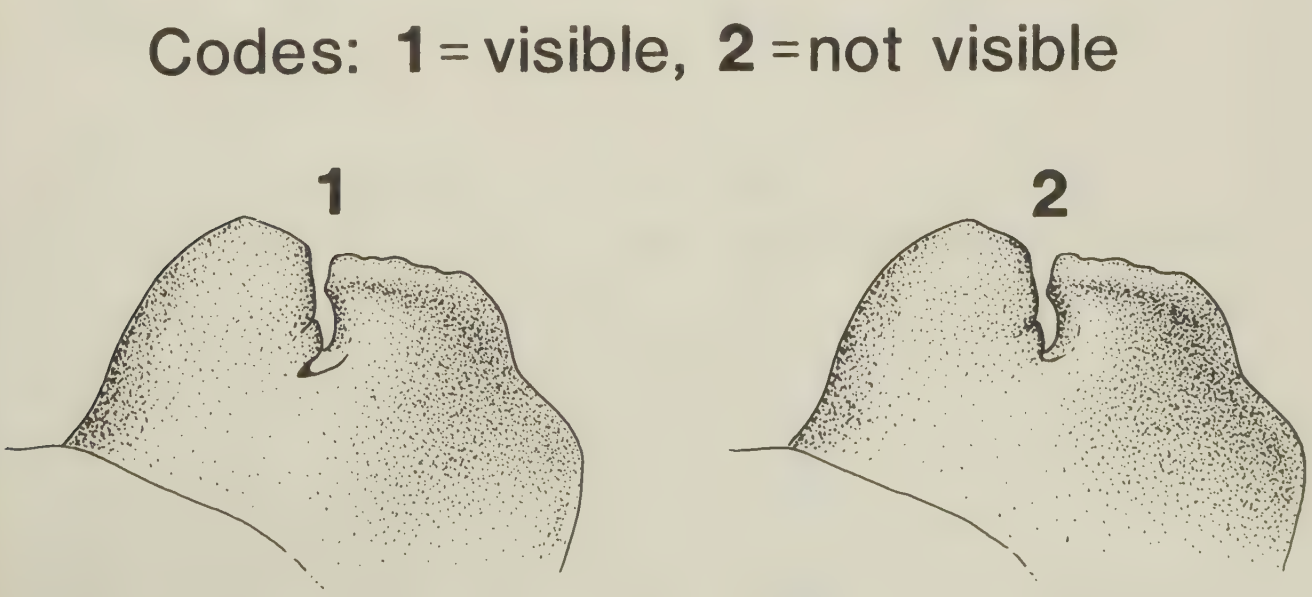
Character 31.

Fenestration(s) in the basoccipital (k. in figure on p. 21).



Character 32. (left and right)

Visibility, in ventro-occipital view of mesially directed foramen between basoccipital and exoccipital process (area l. in figure on p. 21).



THE MANDIBLE

Character 33. (left and right)

Number of mental foramina.

Codes: 1 = 1, 2 = 2, 3 = 3, 4 = 4, 5 = 5, 6 = 6, 7 = 7, 8 = 8, 9 = 9, 10 = 10, 99 = no data.

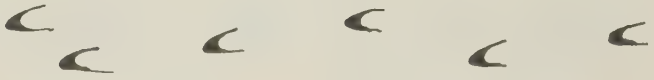
Character 34. (left and right)

Arrangement of mental foramina.

Codes :

1 =foramina lie along a simple curve, e.g.,

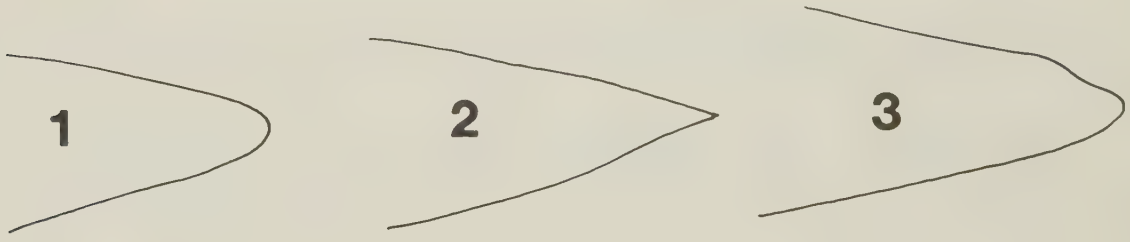
2 =foramina do not lie along a simple curve, e.g.,



Character 35 (left and right)

Shape of anterior end of mandibular fossa.

Codes :



Character 36.

Shape of ventral angle of (left) ramus

Codes :

APPENDIX 2.

Summary of state-frequencies for 36 non-metrical skull characters in 5 single-school samples of S. attenuata (schools I-IV and XI) and 2 of S. longirostris (schools IX and X). Asterisks (*) denote characters for which statistically significant (at >0.05) variation was found among northern offshore samples of S. attenuata (I-IV) see Table 3.

APPENDIX 2

Sample		Position of foramina in PMX Character 1.* State code						Position of large ant. mx foramen 2.						Asymmetry of position of large ant. mx foramen 3.			Vertical penetration of mx? 4.	
		left			right			left			right						left	right
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1(yes)	1(yes)
I	n	20			20			20			20			20			20	20
Stenella attenuata	f	12	8		16	2	2	1		19	7		13	10	2	8	6	2
Northern offshore	c/o	60.0	40.0	0	80.0	10.0	10.0	5.0	0	95.0	35.0	0	65.0	50.0	10.0	40.0	30.0	10.0
II	n	37			37			37			37			37			37	37
Stenella attenuata	f	34	3		33	1	3	2	1	34	13		24	11	4	22	9	3
Northern offshore	c/o	91.9	8.1	0	89.2	2.7	8.1	5.4	2.7	91.9	35.1	0	64.9	29.7	10.8	59.5	24.3	8.1
III	n	62			62			62			62			62			62	62
Stenella attenuata	f	54	6	2	54	2	6	9		53	28	3	31	21	7	34	14	6
Northern offshore	c/o	87.1	9.7	3.2	87.1	3.2	9.7	14.5	0	85.5	45.2	4.8	50.0	33.9	11.3	54.8	22.6	9.7
IV	n	48			48			49			49			49			49	49
Stenella attenuata	f	39	8	1	40	4	4	6	2	41	12	4	33	22	2	25	13	8
Northern offshore	c/o	81.3	16.7	2.1	83.3	8.3	8.3	12.2	4.1	83.7	24.5	8.2	67.3	44.9	4.1	51.0	26.5	16.3
IX	n	21			21			21			21			21			21	21
Stenella longirostris	f			21			21	6		15	6	3	12	7	5	9	3	1
Northern whitebelly	c/o	0	0	100.0	0	0	100.0	28.6	0	71.4	28.6	14.3	57.1	33.3	23.8	42.9	14.3	4.8
X	n	14			14			14			14			14			14	
Stenella longirostris	f	3		11	1		13	1	1	12	4	1	9	3	3	8	5	5
Southern whitebelly	c/o	21.4	0	78.6	7.1	0	92.9	7.1	7.1	85.7	28.6	7.1	64.3	21.4	21.4	57.1	35.7	35.7
XI	n	8			8			8			8			8			8	8
Stenella attenuata	f	1	7		5	3				8			8	2		6	5	3
Coastal	c/o	12.5	87.5	0	62.5	37.5	0	0	0	100.0	100.0	0	0	25.0	0	75.0	62.5	37.5

APPENDIX 2 Continued

Sample		No. of Mx foramina ant. to large ant. mx for. 5.*								No. of Mx foramina post. to ant. edge nares 6.							
		left				right				left				right			
		1	2	3	6	1	2	3	6	1	2	3	6	1	2	3	6
I	n	20				20				20				20			
Stenella attenuata	f				20				20	11			9	4	1		15
Northern offshore	c/o	0	0	0	100.0	0	0	0	100.0	55.0	0	0	45.0	20.0	5.0		75.0
II	n	37				37				37				37			
Stenella attenuata	f	7	1		29	6			31	12	1		24	6	1		30
Northern offshore	c/o	18.9	2.7	0	78.4	16.2	0	0	83.8	32.4	2.7	0	64.9	16.2	2.7		81.1
III	n	62				62				62				62			
Stenella attenuata	f	13	7	1	41	12		4	46	23	3	1	35	20	1		41
Northern offshore	c/o	21.0	11.3	1.6	66.1	19.4	0	6.5	74.2	37.1	4.8	1.6	56.5	32.3	1.6	0	66.1
IV	n	48				48				49				49			
Stenella attenuata	f	8	1		39	6			42	21	1		27	10			39
Northern offshore	c/o	16.7	2.1	0	81.3	12.5	0	0	87.5	42.9	2.1	0	55.1	20.4	0	0	79.6
IX	n	21				21				21				21			
Stenella longirostris	f	9	4	2	6	14	3		4	10	1		10	7			14
Northern whitebelly	c/o	42.9	19.0	9.5	28.6	66.7	14.3	0	19.0	47.6	4.8	0	47.6	33.3	0	0	66.7
X	n	14				14				14				14			
Stenella longirostris	f	6	2		6	4		2	8	8	1		5	7	1		6
Southern whitebelly	c/o	42.9	14.3	0	42.9	28.6	0	14.3	57.1	57.1	7.1	0	35.7	50.0	7.1	0	42.9
XI	n	8				8				8				8			
Stenella attenuata	f	2	1		5	2			6	3			5	1			7
Coastal	c/o	25.0	12.5	0	62.5	25.0	0	0	75.0	37.5	0	0	62.5	25.0	0	0	75.0

APPENDIX 2 Continued

Sample		Exposures of MX through PMX 7.* left 1	2	3	4	5	6	7	8	right 1	2	3	4	5	6	7	8	Spine? 8.*	Mx-occip. contact? 9.* left	right	PMX-NAS contact? 10.
I	n	28								28								1	1	1	1
Stenella attenuata	f	26	1	1						6	19	3						28	28	28	28
Northern offshore	c/o	92.8	3.6	3.6	0	0	0	0	0	21.4	67.9	10.7	0	0	0	0	0	64.3	32.1	39.3	14.3
II	n	37								37											
Stenella attenuata	f	36	1							18	16	3						37	37	37	37
Northern offshore	c/o	97.3	2.7	0	0	0	0	0	0	48.7	43.2	8.1	0	0	0	0	0	14	7	18	8
																		37.8	18.9	48.6	21.6
III	n	62								62											
Stenella attenuata	f	49	9	3		1				26	25	8			2	1		62	62	62	61
Northern offshore	c/o	79.0	14.5	4.8	0	1.5	0	0	0	41.9	40.3	12.9	0	0	3.2	1.5	0	39	21	40	17
																		62.9	33.9	64.5	27.9
IV	n	50								50											
Stenella attenuata	f	39	10		1					20	24	6						50	50	50	50
Northern offshore	c/o	78.0	20.0	0	2.0	0	0	0	0	40.0	48.0	12.0	0	0	0	0	0	41	25	31	17
																		82.0	50.0	62.0	34.0
IX	n	21								21											
Stenella longirostris	f	13	5	1	2					14	7							21	21	21	21
Northern whitebelly	c/o	61.9	23.8	4.8	9.5	0	0	0	0	66.7	33.3	0	0	0	0	0	0	21	8	1	6
																		100.0	38.1	4.8	28.6
X	n	14								14											
Stenella longirostris	f	9	3	1				1		3	7	3			1			14	14	14	13
Southern whitebelly	c/o	64.3	21.4	7.1	0	0	0	7.1	0	21.4	50.0	21.4	0	0	7.1	0	0	12	7	14	5
																		85.7	50.0	100.0	38.5
XI	n	8								8											
Stenella attenuata	f	8								3	4		1					8	8	8	8
Coastal	c/o	100.0	0	0	0	0	0	0	0	37.5	50.0	0	12.5	0	0	0	0	2	1	1	1
																		25.0	12.5	12.5	12.5

APPENDIX 2 Continued

Sample		Formation of edge of ext. nares 11.* left 1	left 2	right 1	right 2	Antorbital notch present? 12.* left	right	Composition of antorb. process 13. 1	2	3	Number of malocclusions 14. 1	2	3	4	5	6	Ridge? 15.* 1	Acc. for? 16. 1	Notch? 17. 1
	n	28		28		28	28	28			21						28	28	28
I	f	6	22	14	14	22	22	27		1	6	6	3	1	2	3	3	1	2
Stenella attenuata	c/o	21.4	78.6	50.0	50.0	78.6	78.6	96.4	0	3.6	28.6	28.6	14.3	4.8	9.5	14.3	10.7	3.6	7.1
Northern offshore																			
	n	37		37		37	36	37			26						37	37	37
II	f	8	29	19	18	25	30	33		4	6	7	8	2	1	2	9	2	6
Stenella attenuata	c/o	21.6	78.4	51.4	48.6	67.6	83.3	89.2	0	10.8	23.1	26.9	30.8	7.7	3.8	7.7	24.3	5.4	16.2
Northern offshore																			
	n	62		61		62	62	60			15						62	62	62
III	f	4	58	34	27	59	58	57		3	5	2	5	2		1	3	0	3
Stenella attenuata	c/o	6.5	93.5	55.7	44.3	95.2	93.5	95.0	0	5.0	33.3	13.3	33.3	13.3	0	6.7	4.8	0	4.8
Northern offshore																			
	n	50		50		49	48	47			29						50	49	50
IV	f	4	46	31	19	44	45	45		2	7	5	7	4	2	4	3	1	2
Stenella attenuata	c/o	8.0	92.0	62.0	38.0	89.8	93.8	95.7	0	4.3	24.1	17.2	24.1	13.8	6.9	13.8	6.0	2.0	4.0
Northern offshore																			
	n	21		21		21	21	21			0						21	21	21
IX	f	1	20	21		21	21	21									21	3	4
Stenella longirostris	c/o	4.8	95.2	100.0	0	100.0	100.0	100.0	0	0							100.0	14.3	19.0
Northern whitebelly																			
	n	14		14		14	14	14			14						14	14	14
X	f	1	13	14		13	14	13	1		5	3	3	2		1	3	14	4
Stenella longirostris	c/o	7.1	92.9	100.0	0	92.9	100.0	92.9	7.1	0	35.7	21.4	21.4	14.3	0	7.1	21.4	100.0	28.6
Southern whitebelly																			
	n	8.1		8		8	8	8			6						8	8	8
XI	f	1	7	7	1	6	7	6	2			1	1	1		3	2	0	0
Stenella attenuata	c/o	12.5	82.5	82.5	12.5	75.0	75.0	75.0	25.0	0	0	16.7	16.7	16.7	0	50.0	25.0	0	0
Coastal																			

APPENDIX 2 Continued

Sample		Occipital fenestrations: Near condyles 18. left: 1	2	3	6	right: 1	2	3	6	In bulges 19.: 1	2	6	Position of post. end of toothrow 20.*: left: 1	2	3	right: 1	2	3
I	n	28				28				28			28			28		
Stenella attenuata	f	4			24	1			27		1	27	4	18	6	3	18	7
Northern offshore	c/o	14.3	0	0	85.7	3.6	0		96.4	0	3.6	96.4	14.3	64.3	21.4	10.7	64.3	25.0
II	n	37				37				37			37			37		
Stenella attenuata	f	5	3		29	6	1		30			37	9	28		8	28	1
Northern offshore	c/o	13.5	8.1	0	78.4	16.2	2.7	0	81.1	0	0	100.0	24.3	75.7	0	21.6	75.7	2.7
III	n	62				62				62			62			62		
Stenella attenuata	f	9			53	7			55	1		61	14	39	9	11	41	10
Northern offshore	c/o	14.5	0	0	85.5	11.3	0	0	88.7	1.6	0	98.4	22.6	62.9	14.5	17.7	66.1	16.1
IV	n	50				50				50			52			50		
Stenella attenuata	f	2	1		47	4	1		45	5		45	15	35	2	14	31	5
Northern offshore	c/o	13.5	8.1	0	78.4	16.2	2.7	0	81.1	10.0	0	90.0	26.0	70.0	4.0	28.0	62.0	10.0
IX	n	21				21				21			21			21		
Stenella longirostris	f	2			19	2			19			21	1	1	19			21
Northern whitebelly	c/o	9.5	0	0	90.5	9.5	0	0	90.5	0	0	100.0	4.8	4.8	90.5	0	0	100.0
X	n	14				14				14			13			13		
Stenella longirostris	f				14	1	13					14		9	4	2	7	4
Southern whitebelly	c/o	0	0	0	100.0	7.1	92.9	0	0	0	0	100.0	0	69.2	30.8	15.4	53.8	30.8
XI	n	8				8				8			8			8		
Stenella attenuata	f				8				8			8	4		4	6		2
Coastal	c/o	0	0	0	100.0	0	0	0	100	0	0	100.0	50.0	0	50.0	75.0	0	25.0

APPENDIX 2 Continued

Sample		Location of MX foramen 21*									No. of MX/palatine foramina 22*									
		left					right				left					right				
		1	2	3	4	5	1	2	3	4	1	2	3	4	5	1	2	3	4	5
I	n	28					28				28					28				
Stenella attenuata	f	8	10	3	7		20	2	4	2	7	15	5	1		5	15	5	1	2
Northern offshore	c/o	28.6	35.7	10.7	25.0	0	71.4	7.1	14.3	7.1	25.0	53.6	17.9	3.6	0	17.9	53.6	17.9	3.6	7.1
II	n	37					37				37					37				
Stenella attenuata	f	27	8	1	1		27	10			16	13	7	1		15	15	7		
Northern offshore	c/o	73.0	21.6	2.7	2.7	0	73.0	27.0	0	0	43.2	35.1	18.9	2.7	0	40.5	40.5	18.9	0	0
III	n	62					62				62					62				
Stenella attenuata	f	25	17	7	10	3	24	13	18	7	5	23	18	12	4	6	21	26	7	2
Northern offshore	c/o	40.3	27.4	11.3	16.1	4.8	38.7	21.0	29.0	11.3	8.1	37.1	29.0	19.4	6.5	9.7	33.9	41.9	11.3	3.2
IV	n	50					50				50					50				
Stenella attenuata	f	34	5	6	5		16	15	15	4	4	22	17	6	1	4	17	17	11	1
Northern offshore	c/o	68.0	10.0	12.0	10.0		32.0	30.0	30.0	8.0	8.0	44.0	34.0	12.0	2.0	8.0	34.0	34.0	22.0	2.0
IX	n	21					21				21					21				
Stenella longirostris	f	18	1		2		15	2	1	3	2	8	8	2	1	3	7	8	3	
Northern whitebelly	c/o	85.7	4.8	0	9.5	0	71.4	9.5	4.8	14.3	9.5	38.1	38.1	9.5	4.8	14.3	33.3	38.1	14.3	0
X	n	13					13				13					13				
Stenella longirostris	f	7	1	2	3		7	1	1	4	1	10		2		2	7	4		
Southern whitebelly	c/o	53.8	7.7	15.4	23.1	0	53.8	7.7	7.7	30.8	7.7	76.9	0	15.4	0	15.4	53.8	30.8	0	0
XI	n	8					8				8					8				
Stenella attenuata	f	1	2	4	1		3	1		4		2	6			1	3	3	1	
Coastal	c/o	12.5	25.0	50.0	12.5	0	37.5	12.5	0	50.0	0	25.0	75.0	0	0	12.5	37.5	37.5	12.5	0

APPENDIX 2 Continued

Sample		Pterygold hamuli 23.	24.	25.	26.*	27.	Shape of posterior margin of basispenoid 28.						Lateral fenestrations in basisphenoid 29.								Mes. fenes. in basisph. 30.
		1	1	1	1	1	1	2	3	4	5	6	1	2	3	4	5	6	7	8	1
I	n	28	28	28	28	28	28						28								
Stenella attenuata	f	12	18	5	5	14	21	1	4	2			10	13		4		1			28
Northern offshore	c/o	42.9	64.3	17.9	17.9	50.0	75.0	3.6	14.3	7.1	0	0	35.7	46.4	0	14.3	0	3.6	0	0	7.1
II	n	37	37	36	37	36	37						36								
Stenella attenuata	f	11	15	6	4	18	23		5	6	2	1	12	21	1		1	1			37
Northern offshore	c/o	29.7	40.5	16.7	10.8	50.0	62.2	0	13.5	16.2	5.4	2.7	33.3	58.3	2.8	0	2.8	2.8	0	0	2.7
III	n	61	62	62	62	62	62						62								
Stenella attenuata	f	34	29	8	2	29	51		9	2			25	23	2	4	1	1	4	2	62
Northern offshore	c/o	55.7	46.8	12.9	3.2	46.8	82.3	0	14.5	3.2	0	0	40.3	37.1	3.2	6.5	1.6	1.6	6.5	3.2	0
IV	n	50	50	50	49	49	50						50								
Stenella attenuata	f	21	27	7	2	22	34	5	8	3			18	29		1		2			50
Northern offshore	c/o	42.0	54.0	14.0	4.1	44.9	68.0	10.0	16.0	6.0	0	0	36.0	58.0	0	2.0	0	4.0	0	0	2
																					4.0
IX	n	19	19	21	19	18	21						21								
Stenella longirostris	f	9	7	5	19	6	14	3	2	2			6	11	3	1					21
Northern whitebelly	c/o	47.4	36.8	23.8	100.0	33.3	66.7	14.3	9.5	9.5	0	0	28.6	52.4	14.3	4.8	0	0	0	0	1
																					4.8
X	n	14	14	14	14	14	14						14								
Stenella longirostris	f	5	8	7	14	2	10	2	1	1			1	9	3				1		14
Southern whitebelly	c/o	35.7	57.1	50.0	100.0	14.3	71.4	14.3	7.1	7.1	0	0	7.1	64.3	21.4	0	0	0	7.1	0	2
																					14.3
XI	n	7	8	8	7	8	8						8								
Stenella attenuata	f	4	3	4	2	4	6	1	1				3	5							8
Coastal	c/o	57.1	37.5	50.0	28.6	50.0	75.0	12.5	12.5	0	0	0	37.5	62.5	0	0	0	0	0	0	2
																					25.0

APPENDIX 2 Continued

Sample		Fenestrations in basoccipital 31.								"Vent-lat-occip." for 32.		Number of mental foramina 33.								
										left	right	left								
		1	2	3	4	5	6	7	8	1	1	2	3	4	5	6	7	8	9	10	11
I	n	28								28	28	25									
Stenella attenuata	f	7	1			1	19			9	10			2	12	8	1	2			
Northern offshore	c/o	25.0	3.6	0	0	3.6	67.9	0	0	32.1	35.7	0	0	8.0	48.0	32.0	4.0	8.0	0	0	0
II	n	37								37	37	36									
Stenella attenuata	f	9		1	1	1	24	1		16	18			4	10	12	6	3		1	
Northern offshore	c/o	24.3	0	2.7	2.7	2.7	64.9	2.7	0	43.2	48.6	0	0	11.1	27.8	33.3	16.7	8.3	0	2.8	0
III	n	61								61	61	28									
Stenella attenuata	f	16	2		1		40	1	1	32	30		1	1	13	8	5				
Northern offshore	c/o	26.2	3.3	0	1.6	0	65.6	1.6	1.6	52.5	49.2	0	3.6	3.6	46.4	28.6	17.9	0	0	0	0
IV	n	50								50	50	33									
Stenella attenuata	f	5	2		1		41	1		24	24			1	10	11	9	1	1		
Northern offshore	c/o	10.0	4.0	0	2	0	82.0	2.0	0	48.0	48.0	0	0	3.0	30.3	33.3	27.3	3.0	3.0	0	0
IX	n	21								21	21	21									
Stenella longirostris	f	6					14	1		6	6	1	1	5	11	2	1				
Northern whitebelly	c/o	28.6	0	0	0	0	66.7	4.8	0	28.6	28.6	4.8	4.8	23.8	52.4	9.5	4.8	0	0	0	0
X	n	14								12	12	13									
Stenella longirostris	f	3					11			2	2			8	5						
Southern whitebelly	c/o	21.4	0	0	0	0	78.6	0	0	16.7	16.7	0	0	61.5	38.5	0	0	0	0	0	0
XI	n	8								8	8	8									
Stenella attenuata	f	1					7			4	3		1	3	1	1	2				
Coastal	c/o	12.5	0	0	0	0	87.5	0	0	50.0	37.5	0	12.5	37.5	12.5	12.5	12.5	0	0	0	0

APPENDIX 2 Continued

Sample		Number of mental foramina 33. right									Ment. for. in line? 34.* left	Ment. for. in line? 34.* right	Shape of ant. end of mandib. fossa 35. left			Shape of ant. end of mandib. fossa 35. right			Ram. ang.? 36.
		3	4	5	6	7	8	9	10	11	1	1	1	2	3	1	2	3	1
I	n	24									25	24	28			28			28
Stenella attenuata	f		3	10	5	5	1				1	9	15	10	3	16	9	3	27
Northern offshore	c/o	0	12.5	41.7	20.8	20.8	4.2	0	0	0	4.0	37.5	53.6	35.7	10.7	57.1	32.1	10.7	96.4
II	n	31									35	31	35			34			34
Stenella attenuata	f	1	6	13	5	5			1		8	11	18	15	2	13	17	3	27
Northern offshore	c/o	3.2	19.4	41.9	16.1	16.1	0	0	3.2	0	22.9	35.5	51.4	42.9	5.7	38.2	50.0	8.8	79.4
III	n	27									28	28	30			30			29
Stenella attenuata	f		3	13	6	4	1				15	11	18	10	2	20	7	3	22
Northern offshore	c/o	0	11.1	48.1	22.2	14.8	3.7	0	0	0	53.6	39.3	60.0	33.3	6.7	66.7	23.3	10.0	75.9
IV	n	30									33	31	39			38			38
Stenella attenuata	f	6	7	7	4	5	1				14	15	26	6	7	32	3	3	29
Northern offshore	c/o	20.0	23.3	23.3	13.3	16.7	3.3	0	0	0	42.4	48.4	66.7	15.4	17.9	84.2	7.9	7.9	76.3
IX	n	21									21	21	21			21			19
Stenella longirostris	f	2	6	6	6	1					10	10	21			21			15
Northern whitebelly	c/o	9.5	28.6	28.6	28.6	4.8	0	0	0	0	47.6	47.6	100.0	0	0	100.0	0	0	78.9
X	n	13									13	13	14			14			14
Stenella longirostris	f	1	6	5			1				9	5	10	1	3	11	3		14
Southern whitebelly	c/o	7.7	46.2	38.5	0	0	7.7	0	0	0	69.2	38.5	71.4	7.1	21.4	78.6	21.4	0	100.0
XI	n	7									8	7	8			8			5
Stenella attenuata	f		1	1	3	1	1				2	2	6		2	8			5
Coastal	c/o	0	14.3	14.3	42.9	14.3	14.3	0	0	0	25.0	28.6	75.0	0	25.0	100.0	0	0	100.0